



**PATENT APPLICATION
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In re Application of

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For: RESIN SHEET, PROCESSES FOR PRODUCING THE SAME, AND
LIQUID CRYSTAL DISPLAYS

DECLARATION UNDER 37 C.F.R. 1.55(b)
(Pursuant to 37 C.F.R. 1.68)

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Sir:

I, Hiroshi Okamoto, do depose, declare and state:

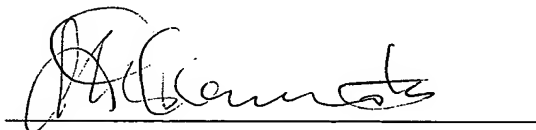
THAT I am a citizen of Japan located at Ark Mori Bldg. 13F, 12-32,
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THAT I understand the Japanese and English languages and that the attached English document is believed to be full, true and faithful translation made by me of Japanese Patent Application No. 2000-370808 FILED December 6, 2000, the claim to the priority date of which application was made in the letter of transmittal submitted with the application as filed, with receipt of the certified copy of said Japanese application being acknowledged by the U.S. Patent Office in the Office Action dated December 3,

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Date: February 6, 2004

A handwritten signature in dark ink, appearing to read 'H. Okamoto', is written over a horizontal line.

Hiroshi Okamoto



[Designation of Document] Specification

[Title of the Invention]

Liquid crystal cell substrate, its production process, and liquid crystal display

[Claims]

[Claim 1] A liquid crystal cell substrate comprising a gas barrier layer, a base layer, and two hard coat layers respectively as the outermost layers, wherein one of the hard coat layers has recesses and protrusions on the outer surface thereof and at least one of the hard coat layers contains transparent particles.

[Claim 2] A liquid crystal cell substrate comprising a gas barrier layer, a base layer, and one hard coat layer as an outermost layer, wherein the hard coat layer has recesses and protrusions on the outer surface thereof and contains transparent particles.

[Claim 3] The liquid crystal cell substrate as claimed in claim 1 or 2, wherein the surface having recesses and protrusions has a surface roughness of 80-500 nm.

[Claim 4] The liquid crystal cell substrate as claimed in claims 1-3, wherein the surface having recesses and protrusions has a peak-to-valley distance of 20-80 nm.

[Claim 5] The liquid crystal cell substrate as claimed in claims 1-4, wherein the transparent particles are spherical particles, the difference in refractive index between the spherical particles and the matrix resin constituting the hard coat layer being 0.03-0.10.

[Claim 6] The liquid crystal cell substrate as claimed in claims 1-5, wherein the base layer comprises an epoxy resin.

[Claim 7] The liquid crystal cell substrate as claimed in claims 1-6, wherein the hard coat layers comprise a urethane resin.

[Claim 8] A process for producing the liquid crystal cell substrate as claimed in claim 1, which includes the step of transferring the shape of recesses formed in a support to thereby form recesses and protrusions on a surface of a hard coat layer.

[Claim 9] A liquid crystal display which uses the liquid crystal cell substrate

as claimed in claims 1-7.

[Detailed Description of the Invention]

[0001]

[Industrial Field of Application]

The present invention relates to a liquid crystal cell substrate which prevents ghosts and glittering, a processes for producing the liquid crystal cell substrate, and a liquid crystal display using the liquid crystal cell substrate.

[0002]

[Prior Art]

In displays such as liquid crystal displays, a technique for improving visibility has been known in which a light-diffusing sheet containing transparent particles is bonded to the viewing side of the liquid crystal cell to prevent the glittering attributable to an illuminating light or to the built-in backlight in the liquid crystal display. A technique is also known in which an antiglare sheet having recesses and protrusions on a surface thereof is bonded to the viewing side of a liquid crystal cell to thereby prevent the so-called ghost phenomenon in which an illuminating light, such as fluorescent light or sunlight, or part of the surrounding objects, e.g., the keyboarder, is reflected on the display.

However, from the standpoint of reducing the thickness and weight of liquid crystal displays, investigations are being made on the impartation of a light-diffusing function or antiglare function to a resin sheet in place of bonding a light-diffusing sheet or antiglare sheet to the viewing side of a liquid crystal cell.

[0003]

[Problems that the Invention is to Solve]

Objects of the present invention are to provide a liquid crystal cell substrate which is thin and lightweight and have an antiglare function for preventing the so-called ghost phenomenon in which an illuminating light, such as fluorescent light or sunlight,

or part of the surrounding objects, e.g., the keyboard, is reflected on the display and a light-diffusing function for preventing the glittering attributable to an illuminating light or to the built-in backlight in the liquid crystal display, a processes for producing the liquid crystal cell substrate, and a liquid crystal display using the liquid crystal cell substrate.

[0004]

The present invention provides a liquid crystal cell substrate comprising a gas barrier layer, a base layer, and two hard coat layers respectively as the outermost layers, wherein one of the hard coat layers has recesses and protrusions on the outer surface (exposed surface) thereof and at least one of the hard coat layers contains transparent particles.

The present invention further provides a liquid crystal cell substrate comprising a gas barrier layer, a base layer, and one hard coat layer as an outermost layer, wherein the hard coat layer has recesses and protrusions on the outer surface thereof and contains transparent particles.

The surface having recesses and protrusions preferably has a surface roughness of 80-500 nm, and a peak-to-valley distance of 20-80 nm.

The transparent particles preferably are such spherical particles that the difference in refractive index between the spherical particles and the matrix resin constituting the hard coat layer is 0.03-0.10.

The base layer preferably comprises an epoxy resin, and the hard coat layers preferably comprise a urethane resin.

The present invention further provides a process for producing the liquid crystal cell substrate which includes the step of transferring the shape of recesses formed in a support to thereby form recesses and protrusions on a surface of a hard coat layer; and a liquid crystal display which uses the liquid crystal cell substrate of the present invention.

[0005]

[Mode for Carrying Out the Invention]

The liquid crystal cell substrate according to the present invention comprises a gas barrier layer, a base layer, and two hard coat layers respectively as the outermost layers, wherein one of the hard coat layers has recesses and protrusions on the outer surface thereof and at least one of the hard coat layers contains transparent particles.

[0006]

The term "at least one of the hard coat layers contains transparent particles" includes: the case where of the two hard coat layers, only the layer having recesses and protrusions on the surface contains transparent particles; the case where of the two hard coat layers, only the layer not having recesses and protrusions on the surface contains transparent particles; and the case where both the hard coat layer having recesses and protrusions on the surface and the hard coat layer not having recesses and protrusions on the surface contain transparent particles.

[0007]

In this case, the sequence of superposition of the base layer and gas barrier layer is not particularly limited. Namely, the liquid crystal cell substrate comprising, from an outermost side, a hard coat layer, a gas barrier layer, a base layer, and a hard coat layer, or the liquid crystal cell substrate comprising, from an outermost side, a hard coat layer, a base layer, a gas barrier layer, and a hard coat layer, can be provided.

[0008]

Another liquid crystal cell substrate of the present invention comprises a gas barrier layer, a base layer, and one hard coat layer as an outermost layer, wherein the hard coat layer has recesses and protrusions on the outer surface thereof and contains transparent particles.

[0009]

In this case also, the sequence of superposition of the base layer and gas barrier

layer is not particularly limited. Namely, the liquid crystal cell substrate comprising, from an outermost side, a hard coat layer, a gas barrier layer, and a base layer, or the liquid crystal cell substrate comprising, from an outermost side, a hard coat layer, a base layer, and a gas barrier layer, can be provided. It is, however, preferred that the gas barrier layer be not an outermost layer, because the gas barrier layer may be inferior to the hard coat layer and base layer in impact resistance and chemical resistance. Namely, the resin sheet comprising, from an outermost side, a hard coat layer, a gas barrier layer, and a base layer is more preferred.

[0010]

Examples of materials usable for forming the hard coat layers in the invention include urethane resins, acrylic resins, polyester resins, poly(vinyl alcohol) resins such as poly(vinyl alcohol) and ethylene/vinyl alcohol copolymers, vinyl chloride resins, and vinylidene chloride resins.

[0011]

Also usable for forming the resin layers are polyarylate resins, sulfone resins, amide resins, imide resins, polyethersulfone resins, polyetherimide resins, polycarbonate resins, silicone resins, fluororesins, polyolefin resins, styrene resins, vinylpyrrolidone resins, cellulosic resins, acrylonitrile resins, and the like. Preferred of these resins are urethane resins, in particular, a urethane acrylate. An appropriate blend or the like of two or more resins can also be used for forming the resin layers.

[0012]

Examples of materials usable for forming the gas barrier layer in the invention include materials having low oxygen permeability, such as vinyl alcohol polymers, e.g., poly(vinyl alcohol), partially saponified poly(vinyl alcohol)s, and ethylene/vinyl alcohol copolymers, polyacrylonitrile, and poly(vinylidene chloride). However, vinyl alcohol polymers are especially preferred from the standpoint of high gas barrier properties.

[0013]

The thickness of the gas barrier layer is preferably 2-10 μm , more preferably 3-5 μm . If the thickness of the organic gas barrier layer is smaller than 2 μm , a sufficient gas barrier function cannot be imparted. If it exceeds 10 μm , the resin sheet comes to have an increased yellowness index (YI).

[0014]

Examples of resins which can be spread for forming the base layer include thermoplastic resins such as polycarbonates, polyarylates, polyethersulfones, polysulfones, polyesters, poly(methyl methacrylate), polyetherimides or polyamides, and thermosetting resins such as epoxy resins, unsaturated polyesters, poly(diallyl phthalate) or poly(isobornyl methacrylate). These resins may be used alone or in combination of two or more thereof, or may be used as a copolymer or mixture with other ingredient(s). Most preferred of these resins are epoxy resins.

[0015]

Examples of the epoxy resins usable for forming an epoxy resin layer in the invention include the bisphenol types, such as bisphenol A, bisphenol F, bisphenol S types and hydrogenated epoxy resins derived from these, the novolac types such as phenol-novolac and cresol-novolac types, the nitrogen-containing cyclic types such as triglycidyl isocyanurate and hydantoin types, the alicyclic type, the aliphatic type, the aromatic types such as naphthalene type, the glycidyl ether type, the low water absorption types such as biphenyl type, the dicyclo type, the ester type, the etherester type, and modifications of these. These resins may be used alone or in combination of two or more thereof. Preferred of those various epoxy resins from the standpoints of discoloration prevention etc., are bisphenol A epoxy resins, alicyclic epoxy resins, and triglycidyl isocyanurate type epoxy resins.

[0016]

From the standpoint of obtaining a resin sheet satisfactory in flexibility, strength, and other properties, it is generally preferred to use such an epoxy resin which has an

epoxy equivalent of 100-1,000 and gives a cured resin having a softening point of 120°C or lower. From the standpoint of obtaining an epoxy resin-containing liquid excellent in applicability, spreadability into sheet, etc., it is preferred to use a two-pack type resin which is liquid at temperatures not higher than the application temperature, in particular at room temperature.

[0017]

A hardener and a hardening accelerator can be suitably incorporated into the epoxy resins. Furthermore, various conventional additives such as an antioxidant, modifier, surfactant, dye, pigment, discoloration inhibitor, and ultraviolet absorber can be suitably incorporated according to need.

[0018]

The hardener is not particularly limited, and one or more suitable hardeners can be used according to the epoxy resin to be used. Examples of the hardener include organic acid compounds such as tetrahydrophthalic acid, methyltetrahydrophthalic acid, hexahydrophthalic acid and methylhexahydrophthalic acid, and amine compounds such as ethylenediamine, propylenediamine, diethylenetriamine, triethylenetetramine, amine adducts of these, m-phenylenediamine, diaminodiphenylmethane and diaminodiphenyl sulfone.

[0019]

Other examples of the hardener include amide compounds such as dicyandiamide and polyamides, hydrazide compounds such as dihydrazide, and imidazole compounds such as methylimidazole, 2-ethyl-4-methylimidazole, ethylimidazole, isopropylimidazole, 2,4-dimethylimidazole, phenylimidazole, undecylimidazole, heptadecylimidazole, and 2-phenyl-4-methylimidazole.

[0020]

Examples of the hardener further include imidazoline compounds such as methylimidazoline, 2-ethyl-4-methylimidazoline, ethylimidazoline,

isopropylimidazoline, 2,4-dimethylimidazoline, phenylimidazoline, undecylimidazoline, heptadecylimidazoline, and 2-phenyl-4-methylimidazoline, and further include phenol compounds, urea compounds, and polysulfide compounds.

[0021]

Acid anhydride compounds also are included in examples of the hardener. Such acid anhydride hardeners can be advantageously used from the standpoints of discoloration prevention, etc. Examples thereof include phthalic anhydride, maleic anhydride, trimellitic anhydride, pyromellitic anhydride, nadic anhydride, glutaric anhydride, tetrahydrophthalic anhydride, methyltetrahydrophthalic anhydride, hexahydrophthalic anhydride, methylhexahydrophthalic anhydride, methylnadic anhydride, dodecenylsuccinic anhydride, dichlorosuccinic anhydride, benzophenonetetracarboxylic anhydride, and chlorendic anhydride.

[0022]

Especially preferred are acid anhydride hardeners which are colorless to light-yellow and have a molecular weight of about 140-200, such as phthalic anhydride, tetrahydrophthalic anhydride, hexahydrophthalic anhydride, and methylhexahydrophthalic anhydride.

[0023]

In the case where an acid anhydride is used as a hardener, an epoxy resin and this hardener are mixed in such a proportion that the amount of the acid anhydride is preferably 0.5-1.5 equivalents, more preferably 0.7-1.2 equivalents, per equivalent of the epoxy groups of the epoxy resin. If the acid anhydride is used in an amount smaller than 0.5 equivalents, the cured resin tends to have an impaired hue. If the acid anhydride is used in an amount exceeding 1.5 equivalents, the cured resin tends to have reduced moisture resistance. In the case of using one or more other hardeners, the range of the amount thereof to be used may be the same as in the case described above.

[0024]

Examples of the hardening accelerator include tertiary amines, imidazole compounds, quaternary ammonium salts, organic metal salts, phosphorus compounds, and urea compounds. Especially preferred of these are tertiary amines, imidazole compounds, and phosphorus compounds. These compounds can be used alone or in combination of two or more thereof.

[0025]

The amount of the hardening accelerator to be incorporated is preferably 0.05-7.0 parts by weight, more preferably 0.2-3.0 parts by weight, per 100 parts by weight of the epoxy resin. If the amount of the hardening accelerator incorporated is smaller than 0.05 parts by weight, a sufficient hardening-accelerating effect cannot be obtained. If the amount thereof exceeds 7.0 parts by weight, there is a possibility that the cured resin might discolor.

[0026]

Examples of the antioxidant include conventional antioxidants such as phenol compounds, amine compounds, organosulfur compounds, and phosphine compounds.

[0027]

Examples of the modifier include conventional modifiers such as glycols, silicones, and alcohols.

[0028]

The surfactant is added for the purpose of obtaining an epoxy resin sheet having a smooth surface when the epoxy resin is formed into a sheet by flow casting and cured while in contact with air. Examples of the surfactant include silicone, acrylic, and fluorochemical surfactants. Especially preferred are silicone surfactants.

[0029]

In the present invention, when a hard coat layer has recesses and protrusions, an antiglare function is imparted. The hard coat layer having recesses and protrusions in the present invention preferably has a surface roughness (Ra) of 80-500 nm. If the

surface roughness (Ra) of the hard coat layer having recesses and protrusions is lower than 80 nm or higher than 500 nm, a sufficient antiglare function cannot be imparted. The term "surface roughness" as used herein means the "arithmetic mean roughness Ra" as provided for in JIS B 0601.

[0030]

The hard coat layer having recesses and protrusions in the present invention preferably has a peak-to-valley distance of 20-80 μm . If the peak-to-valley distance of the hard coat layer is smaller than 20 μm or larger than 80 μm , a sufficient antiglare function cannot be imparted. The term "peak-to-valley distance" as used herein means the "mean distance between recesses and protrusions S_m " as provided for in JIS B 0601.

[0031]

In the present invention, when the hard coat layer as an outermost layer contains transparent particles, a light-diffusing function is imparted. Examples of the transparent particles for use in the present invention include particles of inorganic materials such as glasses and silica and particles of organic materials such as acrylic resins, polyester resins, epoxy resins, melamine resins, urethane resins, polycarbonate resins, polystyrene resins, silicone resins, benzoguanamine resins, melamine/benzoguanamine condensates, and benzoguanamine/formaldehyde condensates. Preferred are spherical particles having such a refractive index that the difference in refractive index between the spherical particles and the matrix resin constituting the hard coat layer is in the range of 0.03-0.10. If the difference in refractive index between the spherical particles and the matrix resin is smaller than 0.03 or larger than 0.10, a sufficient light-diffusing function cannot be imparted.

[0032]

The transparent particles preferably have a particle diameter of 0.5-30 μm . Particle diameters thereof smaller than 0.5 μm are undesirable in that the result is insufficient light diffusion, while particle diameters thereof larger than 30 μm are

undesirable in that the result is uneven light diffusion.

[0033]

The proportion of the transparent particles to the hard coat layer is preferably 1-50% by volume. This proportion by volume can be defined as $[(\text{volume of the transparent particles})/(\text{volume of the hard coat layer})] \times 100$. The "volume of the hard coat layer" herein means the volume of the hard coat layer including the transparent particles. If the proportion of the transparent particles to the hard coat layer is lower than 1% or higher than 50%, a sufficient light-diffusing function cannot be imparted.

[0034]

A process for producing the liquid crystal cell substrate in the present invention includes the step of transferring the shape of recesses formed in a support to thereby form recesses and protrusions on a surface of a hard coat layer.

[0035]

The support is usually in the form of a belt or plate. Examples thereof include an endless belt for flow casting and a flat molding plate for casting.

In order for the support to give a hard coat layer having recesses and protrusions, the support preferably has a surface roughness (Ra) of 80-500 nm and a peak-to-valley distance of 20-80 μm .

[0036]

In the flow casting method, a resin solution for hard-coat layer formation is applied to a support having recesses and protrusions and then dried to form a hard coat layer. Thereon are superposed a gas barrier layer and a base layer. The resulting multilayer structure is peeled from the support to thereby obtain a liquid crystal cell substrate in which the hard coat layer has recesses and protrusions formed thereon.

When another hard coat layer is formed on that multilayer structure on the side opposite the support side, then a liquid crystal cell substrate having two hard coat layers is obtained. In this case, the hard coat layer thus formed has no recesses and

protrusions.

[0037]

In the present invention, when a resin solution for hard coat layer formation which contains transparent particles is applied and then dried, a hard coat layer containing transparent particles can be formed.

[0038]

In the casting method, a resin solution for hard coat layer formation is first applied to a casting plate having a surface with recesses and protrusions and to a casting plate having an even surface, and the solution applied is dried to form hard coat layers. Subsequently, a liquid containing a resin for gas barrier layer formation is applied to either of the two casting plates and then dried to form a gas barrier layer. These two casting plates are assembled through a spacer and a sealing material so that the resin-coated sides face each other. Subsequently, a liquid containing a resin for base layer formation is injected into the space between the casting plates and cured to form a base layer. The resulting multilayer resin structure is peeled from the two casting plates. Thus, a liquid crystal cell substrate can be obtained in which one of the hard coat layers has recesses and protrusions formed by the transfer of the shape of recesses formed in one of the supports.

[0039]

In this casting method also, a hard coat layer containing transparent particles can be formed by incorporating transparent particles into a resin solution for hard coat layer formation and applying and drying the solution.

[0040]

The casting plate having recesses and protrusions for use in the casting method also preferably has a surface roughness (Ra) of 80-500 nm and a peak-to-valley distance of 20-80 μm .

[0041]

An embodiment of one of the above-described processes according to the present invention is illustrated in Fig. 1. In the process shown in Fig. 1, a liquid crystal cell substrate is continuously produced by the flow casting method using an endless belt as a support.

[0042]

In the flow casting method shown in Fig. 1, a support comprising an endless belt 1 is caused to run through a driving drum 4 and a subsidiary drum 5 at a constant speed of, e.g., 0.1-50 m/min, preferably 0.2-5 m/min. While the belt 1 is thus kept being run, a resin solution for hard coat layer formation and a liquid containing a resin for gas barrier layer formation are applied thereto through a die 7 and a die 9, respectively, and the resulting coatings are dried or cured optionally with heating, light irradiation, etc., to give coating films 10 and 11. In this embodiment, the apparatus is equipped with a heater 3 and a UV curing device 8.

The endless belt 1 has recesses and protrusions. The endless belt 1 preferably has a surface roughness (Ra) of 80-500 nm and a peak-to-valley distance of 20-80 μm .

A hard coat layer containing transparent particles can be formed by incorporating transparent particles into the resin solution for hard coat layer formation and applying and drying the solution.

[0043]

Subsequently, a liquid containing a resin for base layer formation is applied in a sheet form to the coating films 10 and 11 through a die 2. The resulting coating is completely cured by heating or light irradiation to form a coating film 6. In this embodiment, the apparatus is equipped with a heater 3. Heating may be conducted with hot air, an infrared heater, or the like or a combination of two or more of these. In the case of hot-air drying, the wind velocity is generally 0.1-5 m/sec, but is preferably 0.2-1 m/sec in the heating of a liquid containing a thermoplastic or thermosetting resin.

[0044]

The heater 3 preferably has about ten zones so as to control viscosity changes, i.e., the viscosity decrease due to the temperature dependence of the resin-containing liquid and the viscosity increase due to a curing reaction. In each zone, the coating can be heated from the upper or lower side of the endless belt or from both sides. The heating temperature is preferably 30-250°C. The accuracy of heating temperature is preferably within $\pm 0.5^{\circ}\text{C}/\text{cm}$, more preferably within $\pm 0.1^{\circ}\text{C}/\text{cm}$. If the heating temperature is lower than 30°C, the resin for base layer formation is less apt to cure. If the heating temperature exceeds 250°C, the viscosity of the liquid containing a resin for base layer formation becomes so low that the resulting resin sheet has an impaired thickness precision. Furthermore, if the accuracy of heating temperature is outside the range of $\pm 0.5^{\circ}\text{C}/\text{cm}$, the resulting resin sheet tends to have an impaired thickness precision and an appearance failure.

[0045]

The die 2 through which the liquid containing a resin for base layer formation is ejected has a temperature of preferably 10-40°C, more preferably 20-30°C, and has a temperature accuracy of preferably within $\pm 0.5^{\circ}\text{C}$, more preferably within $\pm 0.1^{\circ}\text{C}$. If the temperature of the die is lower than 10°C, the liquid containing a resin for base layer formation has an increased viscosity, resulting in a problem concerning application. If the temperature thereof exceeds 40°C, the resin for base layer formation begins to cure within the die, making the application difficult. Furthermore, if the accuracy of the die temperature is outside the range of $\pm 0.5^{\circ}\text{C}$, the resulting resin sheet tends to have an impaired thickness precision and an appearance failure.

[0046]

The viscosity of the liquid containing a resin for base layer formation to be ejected is preferably 0.1-50 Pa·s. For extrusion coating, the viscosity thereof is preferably 15-30 Pa·s. If the viscosity of the resin-containing liquid is lower than 0.1

Pa·s, the resulting resin sheet has an impaired thickness precision. If the viscosity of the resin-containing liquid exceeds 50 Pa·s, the liquid has poor applicability.

[0047]

Preferred examples of methods for applying the liquid containing a resin for base layer formation include curtain coating, extrusion coating, and roll coating. Especially preferred is extrusion coating.

[0048]

The heater has guide rolls on the back side of the endless belt so that the horizontal level of the belt can be regulated with a horizontal-level sensor. The horizontal level of the substrate is preferably not higher than 1 mm/[5 x (effective width)] mm, more preferably not higher than 1 mm/[40 x (effective width)] mm. If the horizontal level thereof is higher than 1 mm/[5 x (effective width)] mm, the resulting resin sheet has an impaired thickness precision.

[0049]

A liquid crystal cell substrate having two hard coat layers can be obtained by the flow casting method. Specifically, a liquid containing a resin for hard coat layer formation is applied to the outermost layer located on the side opposite the endless belt and the resulting coating is dried or cured optionally with heating, light irradiation, etc., whereby the desired resin sheet can be obtained. In this case, the multilayer structure composed of a first hard coat layer, a gas barrier layer, and a base layer can be peeled from the endless belt 1 before a second hard coat layer is formed by spin coating or coating with a single-die coater or the like. It is also possible to form a hard coat layer containing transparent particles by incorporating transparent particles into the resin solution for hard coat layer formation.

[0050]

A dam for flow prevention may be formed along each edge of the substrate using a heat-resistant resin. Preferred examples thereof include poly(ethylene

terephthalate).

[0051]

For recovering the resin sheet from the substrate, a means for peeling can be used if desired. From the standpoint of cracking prevention, etc., this recovery is preferably conducted at high temperature, e.g., at a temperature not lower than the glass transition points of the resins. The continuous resin sheet thus formed may be recovered after having been cut into an appropriate size with a suitable cutting means, e.g., a laser beam, ultrasonic cutter, dicing, or water jet. According to the flow casting method described above, the rate of production can be easily controlled by regulating the traveling speed of the spread layers through the support. The thickness of the resin sheet to be obtained also can be easily controlled by regulating the traveling speed of the spread layers and the spread amounts thereof.

[0052]

In the case where the liquid crystal cell substrate of the present invention is used as a viewing-side substrate to fabricate a liquid crystal display, it should be disposed so that the viewing-side outermost surface is that surface of the liquid crystal cell substrate which has recesses and protrusions. Namely, a polarizing film cannot be disposed on the viewing side of the liquid crystal cell substrate. Because of this, the liquid crystals usable in this display are limited to those which do not utilize a polarized light, such as cholesteric liquid crystals and polymer dispersion type liquid crystals. Use of the liquid crystal cell substrate colored black as a substrate disposed opposite to the viewing side is effective in preventing the light which has passed through the liquid crystal layer from being reflected to generate an inversion light and in thereby improving a display contrast.

[0053]

The invention will be explained below in more detail by reference to the following Examples, but the invention should not be construed as being limited to these

Examples in any way.

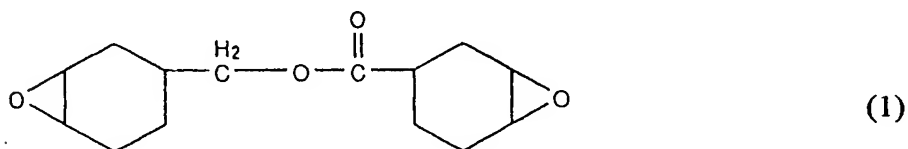
[0054]

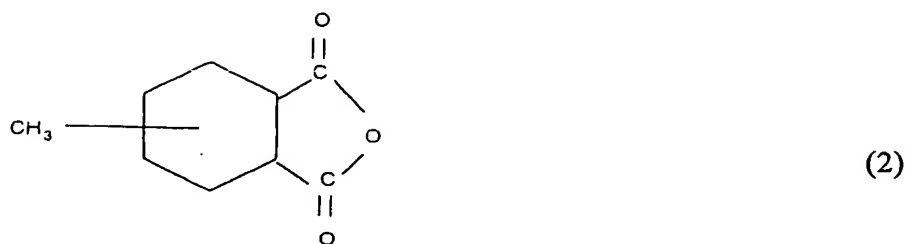
EXAMPLE 1

450 Parts by weight of toluene was added to a mixture of 100 parts by weight of UV-curable resin NK Oligo UN-01 (manufactured by Shin- Nakamura Chemical Co., Ltd.; solid content, 85%), 3 parts by weight of Irgacure #184 (manufactured by Ciba Specialty Chemicals), and 28 parts by weight of synthetic silica particles having an average particle diameter of 1.8 μm . The resulting mixture was homogenized by stirring to obtain a resin solution for forming a transparent resin-containing hard coat layer. This resin solution had a solid concentration of 20%.

450 Parts by weight of toluene was added to a mixture of 100 parts by weight of UV-curable resin NK Oligo UN-01 (manufactured by Shin-Nakamura Chemical Co., Ltd.; solid content, 85%) and 3 parts by weight of Irgacure #184 (manufactured by Ciba Specialty Chemicals). The resulting mixture was homogenized by stirring to obtain a resin solution for hard coat layer formation which had a solid concentration of 16%.

To 400 parts by weight of 3,4-epoxycyclohexylmethyl 3,4-epoxycyclohexanecarboxylate represented by the following formula (1) were added 500 parts by weight of methylhexahydrophthalic anhydride represented by the following formula (2), 15 parts by weight of tetra-n-butylphosphonium o,o-diethyl phosphorodithioate represented by the following formula (3), 9 parts by weight of glycerol, and 1 part by weight of a surfactant. The resulting mixture was homogenized by stirring to obtain a liquid containing a resin for base layer formation.





[0055]

Subsequently, a liquid crystal cell substrate was produced by the casting method using the casting plates shown in Fig. 2. The method for production used is explained below by reference to Fig. 2.

[0056]

One of the casting plates shown in Fig. 2 was an even surface casting plate having dimensions of 450 mm x 450 mm and a surface roughness Ra of 5 nm shown in Figs. 2-13, and the other was a surface-processed casting plate 20 which had dimensions of 450 mm x 450 mm and had undergone a surface processing so as to have a surface roughness Ra of 100 nm and a peak-to-valley distance of 45 μm shown in Figs. 2-14. First, the resin solution for forming a transparent particle-containing hard coat layer was applied by spin coating to the even surface casting plate shown in Figs. 2-13 and then dried to remove the toluene. The resulting coating was irradiated with ultraviolet (center wavelength, 254 nm; integrated quantity of light, 2,000 mJ/cm^2) to form a hard coat layer containing transparent particles and having a thickness of 2 μm . Subsequently, the resin solution for hard coat layer formation was applied by spin coating to the processed side of the surface-processed casting plate shown in Figs. 2-14

and then dried to remove the toluene. The resulting coating was irradiated with ultraviolet (center wavelength, 254 nm; integrated quantity of light, 2,000 mJ/cm²) to form a hard coat layer which, excluding the protrusions thereof, had a thickness of 2 μm.

[0057]

Thereafter, a 5.5% by weight aqueous solution of poly(vinyl alcohol) was applied by spin coating to the hard coat layer formed on the even surface casting plate shown in Figs. 2-13, and then dried and cured to form a gas barrier layer having a thickness of 3.7 μm.

[0058]

A casting mold was fabricated by assembling the two casting plates through a spacer for gap regulation and a sealing material in the manner shown in Fig. 2 so that the respective resin-coated sides faced each other and the space between the plates had a width of 400 μm.

[0059]

Into the space between the two casting plates was injected the liquid prepared above containing a resin for base layer formation. The resin-containing liquid was cured by heating at 120°C for 30 minutes and then at 180°C for 1 hour.

Thereafter, the two casting plates were disassembled and the resulting resin layer was peeled from the plates to obtain a resin sheet (a).

In the liquid crystal cell substrate (a) obtained, the side to which the shape of the recesses and protrusions of the casting plate 20 had been transferred had a surface roughness Ra of 100 nm and a peak-to-valley distance of 45 μm, and the other side had a surface roughness Ra of 5 nm. The liquid crystal cell substrate (a) had an average thickness of 400 μm and a standard deviation in thickness of 9 μm.

[0060]

Another liquid crystal cell substrate was produced in the following manner. This

resin sheet was one to be used in combination with the liquid crystal cell substrate (a) for interposing a liquid crystal therebetween. First, the resin solution for hard coat layer formation was applied to two even surface casting plates and dried to form hard coat layers. Subsequently, a casting mold was fabricated by assembling the two casting plates through a spacer for gap regulation and a sealing material in the manner shown in Fig. 2 so that the respective resin-coated sides faced each other and the space between the casting plates had a width of 400 μm .

[0061]

Black pigment Mitsubishi Carbon Black MA100 was dispersed into the liquid containing a resin for base layer formation in a resin-containing liquid/MA100 ratio of 10/1 by weight. This pigmented liquid for base layer formation was injected into the space between the two casting plates and then cured by heating at 120°C for 30 minutes and then at 180°C for 1 hour. The resulting liquid crystal cell substrate (b) was taken out of the mold.

The liquid crystal cell substrate (b) obtained had a surface roughness Ra of 4 nm on each side, and had an average thickness of 400 μm and a standard deviation in thickness of 8 μm .

[0062]

The liquid crystal cell substrates (a) and (b) obtained were cut into a given shape and then treated with a plasma in an argon atmosphere. On the resin sheets thus treated was deposited a thin film of indium-tin oxide (ITO) by sputtering. Thus, transparent substrates for liquid crystals were produced.

The ITO film deposition was conducted on that side of the liquid crystal cell substrate (a) which had no recesses and protrusions and on either side of the liquid crystal cell substrate (b).

Thereafter, the ITO thin film of the liquid crystal cell substrate (a) was divided into two parts. The liquid crystal cell substrates (a) and (b) were disposed face to face

through a spacer for gap regulation comprising spherical glass beads so that the respective ITO thin films faced each other and the respective directions of rubbing were perpendicular to each other. The liquid crystal cell substrates (a) and (b) thus disposed were fixed with a sealing material. Subsequently, a solution prepared by homogeneously mixing 10 parts of trimethylpropane triacrylate (TMPTA) with 10 parts by weight of 2-hydroxyethyl acrylate (HEA), 25 parts by weight of an acrylic oligomer ("M-1200", manufactured by Toagosei Chemical Industry Co., Ltd.), 0.5 parts by weight of photocuring initiator "Durocure-1173" manufactured by Merck, and 50 parts by weight of liquid crystal "E7" manufactured by BDH was injected into the space between the liquid crystal cell substrates (a) and (b). This assembly was irradiated with ultraviolet from the liquid crystal cell substrate (a) side to thereby produce a liquid crystal cell as shown in Fig. 3.

[0063]

EXAMPLE 2

A resin sheet was produced by the flow casting method using the apparatus shown in Fig. 1. First, the resin solution for forming a transparent particle-containing hard coat layer prepared in Example 1 was ejected from the die 7 and flow cast on the stainless steel endless belt 1 (surface roughness Ra, 100 nm; peak-to-valley distance, 40 μ m) at a belt running speed of 0.2 m/min. After the toluene was volatilized, the coating was cured with the UV curing device 8 (center wavelength, 254 nm; integrated quantity of light, 2,000 mJ/cm²) to obtain a hard coat layer containing transparent particles and having a thickness of 5 μ m and a width of 500 mm.

[0064]

Subsequently, a 5.5% by weight aqueous solution of poly(vinyl alcohol) was ejected from the die 9 and flow cast on the hard coat layer. The coating was dried with heating (60°C x 10 min) to obtain a gas barrier layer having a thickness of 4 μ m and a width of 450 mm.

[0065]

A heat-resistant PET base tape having a width of 40 mm (MT-3155, manufactured by Nitto Denko Corp.) was applied to each edge of the resulting two-layer structure composed of the hard coat layer and gas barrier layer. The liquid containing a resin for base layer formation described above (20 Pa·s, 25°C) was ejected from the die 2 and flow cast on the resin layer at a width of 430 mm. The coating was dried by heating with the heater 3 at 90°C for 5 minutes, subsequently at 120°C for 5 minutes, and then at 140°C for 15 minutes. On the drum 5 kept at 130°C, the resulting multilayered coating was peeled from the stainless steel endless belt at the interface between the belt and the hard coat layer. Thus, a liquid crystal cell substrate (c) having a width of 430 mm was obtained. In the coating operation, the support in the heater was regulated so as to have a horizontal level of 200 $\mu\text{m}/1,000 \text{ mm}$, and the coating was dried with hot air from the upper and lower sides of the support, the accuracy of heating temperature being 0.4°C/cm.

[0066]

The liquid crystal cell substrate (c) obtained was cut perpendicularly to the machine direction at intervals of 490 mm to obtain cut pieces of 490 mm by 490 mm. The liquid crystal cell substrate (c) obtained had an average thickness of 400 μm and a standard deviation in thickness of 7 μm .

The values of average thickness and standard deviation in thickness were obtained from the found thickness values for sixty points within an area of 480 mm by 480 mm.

The liquid crystal cell substrate (c) had surface roughnesses R_a of 0.2 nm on the base layer side and 100 nm on the hard coat layer side. The surface of the hard coat layer had a peak-to-valley distance of 40 μm . Each value of surface roughness is the average of the found values for ten points within an area of 480 mm by 480 mm.

[0067]

Subsequently, an ITO thin film was deposited on the base layer side of the liquid crystal cell substrate (c). This liquid crystal cell substrate was used in combination with a liquid crystal cell substrate (b) in the same manner as in Example 1 to produce a liquid crystal cell as shown in Fig. 4.

[0068]

COMPARATIVE EXAMPLE 1

A liquid crystal cell substrate (d) was produced in the same manner as in Example 1, except that the resin solution for hard coat layer formation prepared in Example 1 was applied to two even surface casting plates made of metal. This liquid crystal cell substrate was used in combination with a liquid crystal cell substrate (b) in the same manner as in Example 1 to produce a liquid crystal cell.

[0069]

EVALUATION TEST

The liquid crystal cells produced in Examples 1-2 and Comparative Example 1 were used to fabricate liquid crystal displays. In a dark room, the liquid crystal displays were illuminated with a ring-shaped illuminator at an angle of 20°. Under these conditions, each liquid crystal display was examined for the display quality of a black picture while applying a voltage thereto, and was further examined for the display quality of a white picture while applying no voltage thereto.

[0070]

The displays employing the liquid crystal cells obtained in Examples 1-2 had satisfactory display quality with respect to both the black picture and the white picture. In contrast, in the display employing the liquid crystal cell obtained in Comparative Example 1, the ring-shaped illuminator was reflected on the display bearing black picture. Furthermore, this comparative display bearing the white picture glittered probably due to reflection of the illuminating light on the liquid crystal cell surface.

[0071]

[Advantage of the Invention]

Since the liquid crystal cell substrates of the present invention are resin-based sheets, they are thinner and more lightweight than glass-based substrates. The liquid crystal cell substrates of the present invention have as an outermost layer a hard coat layer having recesses and protrusions, and therefore have an antiglare function for preventing the so-called ghost phenomenon in which an illuminating light, such as fluorescent light or sunlight, or part of the surrounding objects, e.g., the keyboard, is reflected on the display. Further, since the hard coat layer as an outermost layer contains transparent particles, the liquid crystal cell substrates have a light-diffusing function for preventing the glittering attributable to an illuminating light or to the built-in backlight in the liquid crystal display. This impartation of an antiglare function or light-diffusing function to a liquid crystal cell substrate eliminates the necessity of bonding an antiglare sheet or light-diffusing sheet to the viewing side of a liquid crystal cell. As a result, the thickness and weight of liquid crystal cells can be reduced.

[0071]

[Brief Description of the Drawings]

[Fig. 1] One example of a process for producing a liquid crystal cell substrate by the flow casting method.

[Fig. 2] One example of a process for producing a liquid crystal cell substrate by the casting method.

[Fig. 3] Liquid crystal cell of Example 1.

[Fig. 4] Liquid crystal cell of Example 2.

[Fig. 5] Liquid crystal cell of Comparative Example 1.

[Description of the Reference Numerals]

1: endless belt (substrate)

2: die for base layer formation

- 3: heater
- 4: driving drum
- 5: subsidiary drum
- 6: base layer
- 7: die for hard coat layer formation
- 8: UV curing device
- 9: die for gas barrier layer formation
- 10: gas barrier layer
- 11: hard coat layer
- 12: tape for edge reinforcement
- 13: even surface casting plate
- 14: surface-processed casting plate
- 15: sealing material
- 16: spacer for gap regulation
- 17: hard coat layer having recesses and projections on the surface
- 18: organic gas barrier layer
- 19: base layer
- 20: hard coat layer⁵ containing transparent particles
- 21: ITO
- 22: rubbing film
- 23: liquid crystal
- 24: base layer having black pigment
- 25: hard coat layer
- 26: hard coat layer having recesses and projections on the surface and containing transparent particles

[Designation of Document] Abstract

[Abstract]

[Problem]

Objects of the present invention are to provide liquid crystal cell substrates which are thin and lightweight and have an antiglare function for preventing the so-called ghost phenomenon in which an illuminating light, such as fluorescent light or sunlight, or part of the surrounding objects, e.g., the keyboarder, is reflected on the display and/or a light-diffusing function for preventing the glittering attributable to an illuminating light or to the built-in backlight in the liquid crystal display; processes for producing the liquid crystal cell substrates; and liquid crystal displays using the liquid crystal cell substrates.

[Means for Resolution]

A liquid crystal cell substrate comprising a gas barrier layer, a base layer, and two hard coat layers respectively as the outermost layers, wherein one of the hard coat layers has recesses and protrusions on the outer surface thereof and at least one of the hard coat layers contains transparent particles.

[Selected Drawing] Fig. 1

FIG. 1

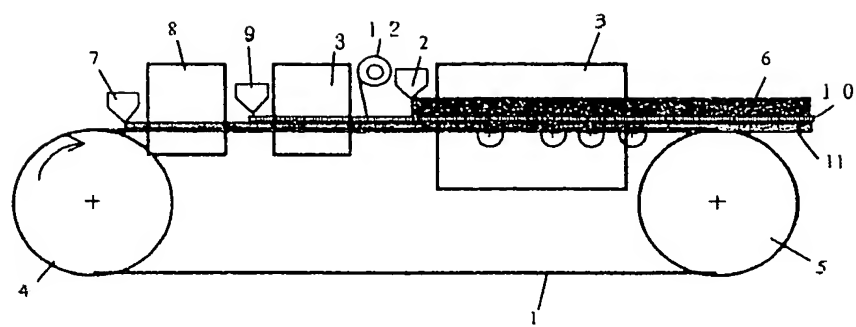


FIG. 2

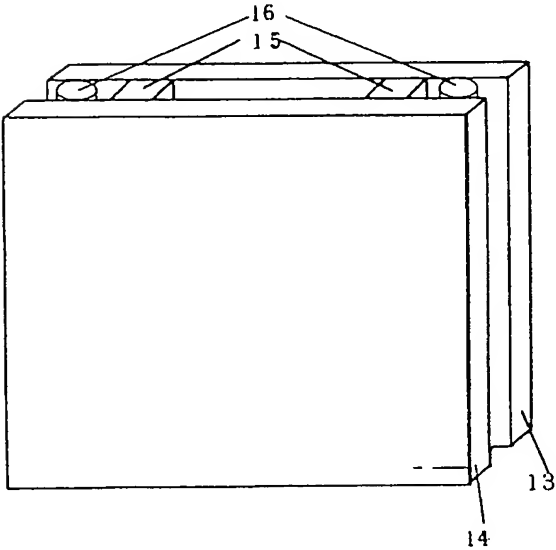


FIG. 3

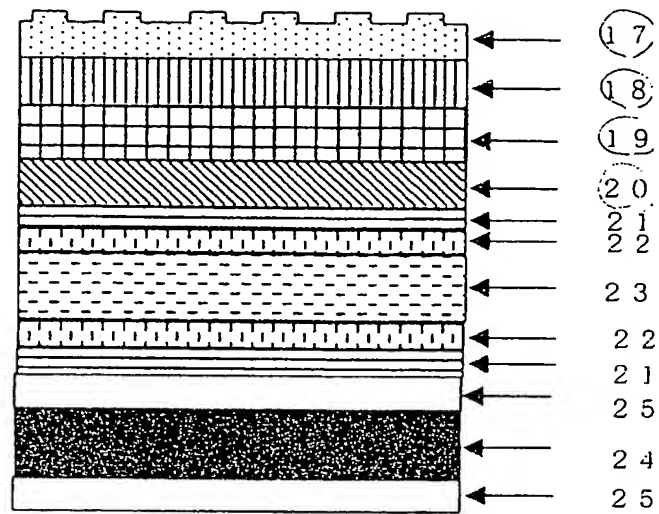


FIG. 4

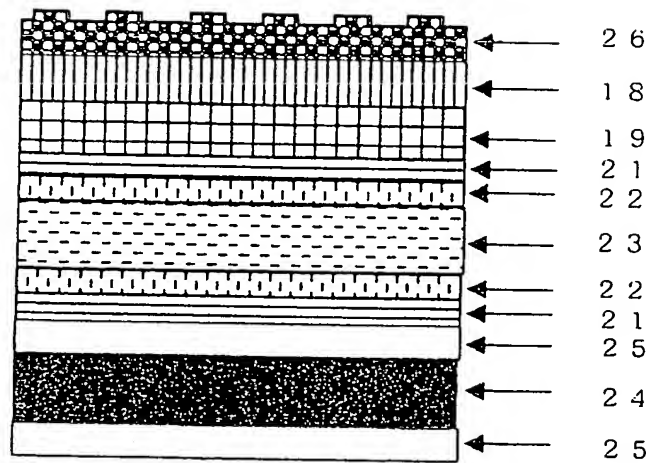


FIG. 5

